
AST403 — Galaxies and Intergalactic Medium

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Name:

Due Date: Feb 14 2026, 11:59 PM

Student Number:

Homework: Number 2

Problem 1

- (a) Approximately how many times has the Sun circled the center of the Galaxy since the star's formation? Age of the Sun is 4.56 Gyr(2)
- (b) The globular cluster IAU C0923-545 has an integrated apparent visual magnitude of $m_V = +13.0$ and an integrated absolute visual magnitude of $M_V = -4.15$. It is located 9.0 kpc from Earth and is 11.9 kpc from the Galactic center, just 0.5 kpc south of the Galactic midplane.
- (1) Estimate the amount of interstellar extinction between IAU C0923-545 and Earth. (2)
- (2) What is the amount of interstellar extinction per kiloparsec? (1)

Problem 2

- (a) From Eq. (24.5), derive an expression for $\log_{10} A_M(m)$ as a function of m for stars of the same absolute magnitude and M–K spectral classification, assuming a constant stellar number density. (3)
- (b) If observations are made in apparent magnitude bins separated by one (i.e., $\delta m = 1$), calculate

$$\Delta \log_{10} A_M(m) \equiv \log_{10} A_M(m+1) - \log_{10} A_M(m) \quad (2)$$

Problem 3

- (a) Plot the thin disk's luminosity density (Eq. 24.10) as a function of z for $R = 8$ kpc. (3)
- (b) Prove that for $z \gg z_0$,

$$L(R, z) \cong 4L_0 e^{-R/R_h} e^{-2z/z_0}$$

and so $z_0 = 2z_{thin}$ is the effective scale height of the luminosity density function. (2)

Problem 4

- (a) Assuming that Eq. (24.51) is valid for any arbitrary distance from the center of the Galaxy, show that the amount of dark matter interior to a radius r is given by the expression

$$M_r = 4\pi\rho_0 a^2 [r - a \tan^{-1}(r/a)]$$

and so $z_0 = 2z_{thin}$ is the effective scale height of the luminosity density function. (3)

- (b) If $5.4 \times 10^{11} M_\odot$ of dark matter is located within 50 kpc of the Galactic center, determine ρ_0 in units of $M_\odot \text{pc}^{-3}$. Repeat your calculation if $1.9 \times 10^{12} M_\odot$ is located within 230 kpc of the Galactic center. Assume that $a = 2.8$ kpc. (2)

Problem 5 Using Eq. (24.52) for the density profile of the dark matter halo, show that

- (a) $\rho_{NFW} \propto r^{-1}$ for $r \ll a$, and $\rho_{NFW} \propto r^{-3}$ for $r \gg a$. (3)
- (b) the integral of the mass from $r = 0$ to $r \rightarrow \infty$ is infinite. (2)